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Bulletin No. 91 - Arid Farming in Utah: First Report of the State Experimental Arid Farms

John A. Widtsoe

Lewis A. Merrill

EXPERIMENT STATION

—OF—

THE AGRICULTURAL COLLEGE

OF UTAH

BULLETIN NO. 91.

ARID FARMING IN UTAH.

First Report of the

STATE EXPERIMENTAL ARID FARMS.

JANUARY, 1905.

LOGAN, UTAH

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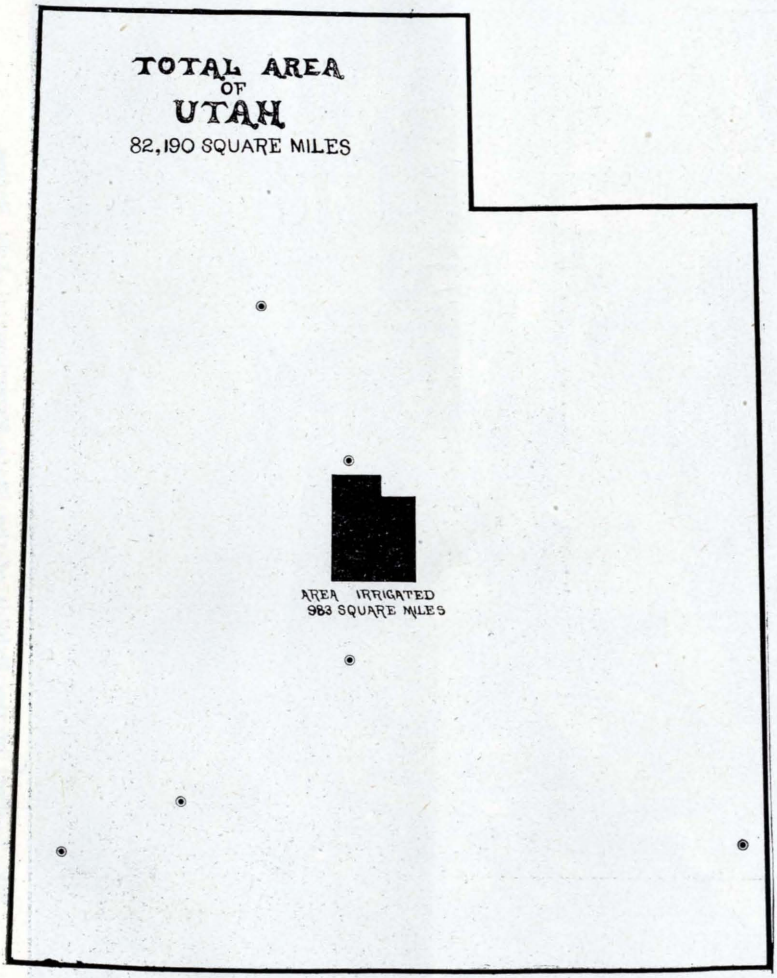

Fig. 1.—Showing the Relative Areas of Irrigated and Arid Land in Utah. (The Circles Represent the Locations of the Experimental Farms.)

Fig. 2.—Part of the Exhibit of the State Experimental Arid Farms.
(Utah State Fair, October, 1904.)

Fig. 3.—Part of the Exhibit of the State Experimental Arid Farms.
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Fig. 6.—After Threshing on One of the Experimental Farms.

Fig. 7.—Method of Threshing from Small Plats on the Experimental Farms.

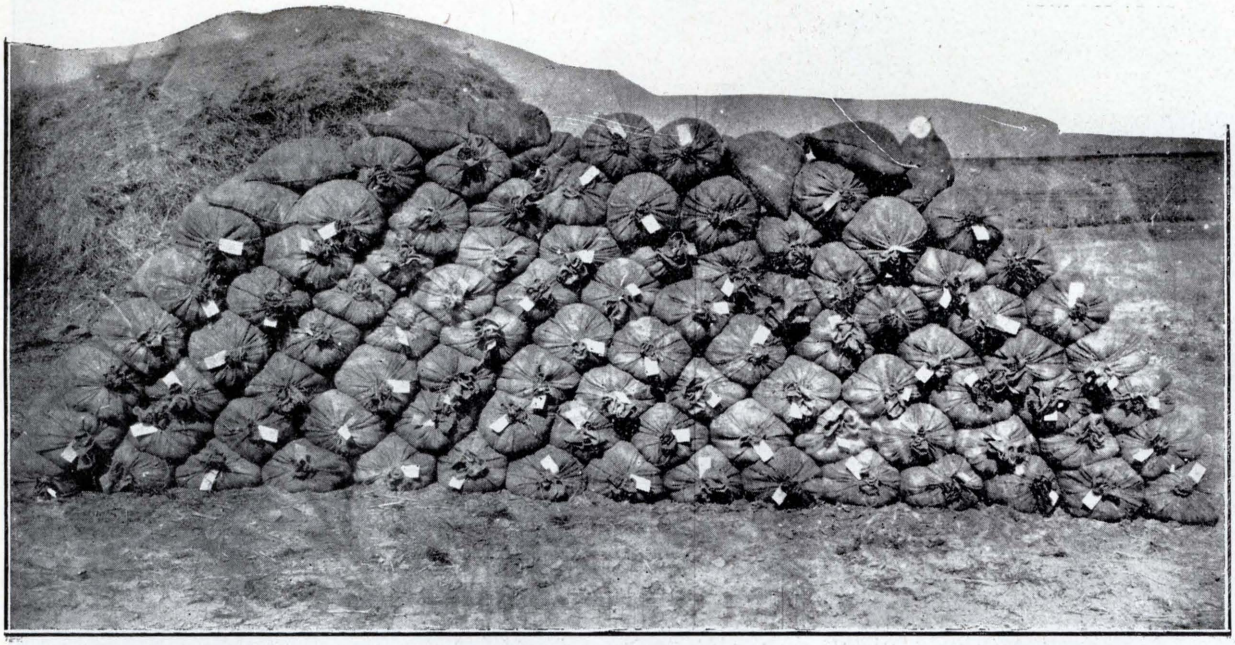

Fig. 8.—Grain Ready for Shipment from one of the Experimental Farms.

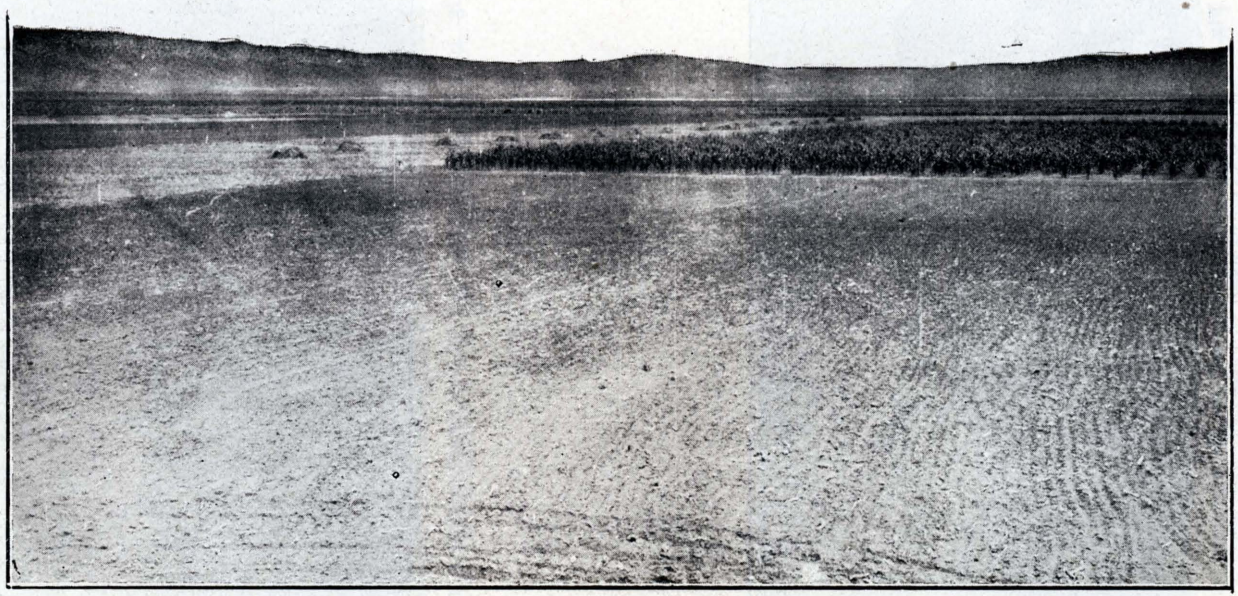

Fig. 9.—View on One of the Experimental Farms.

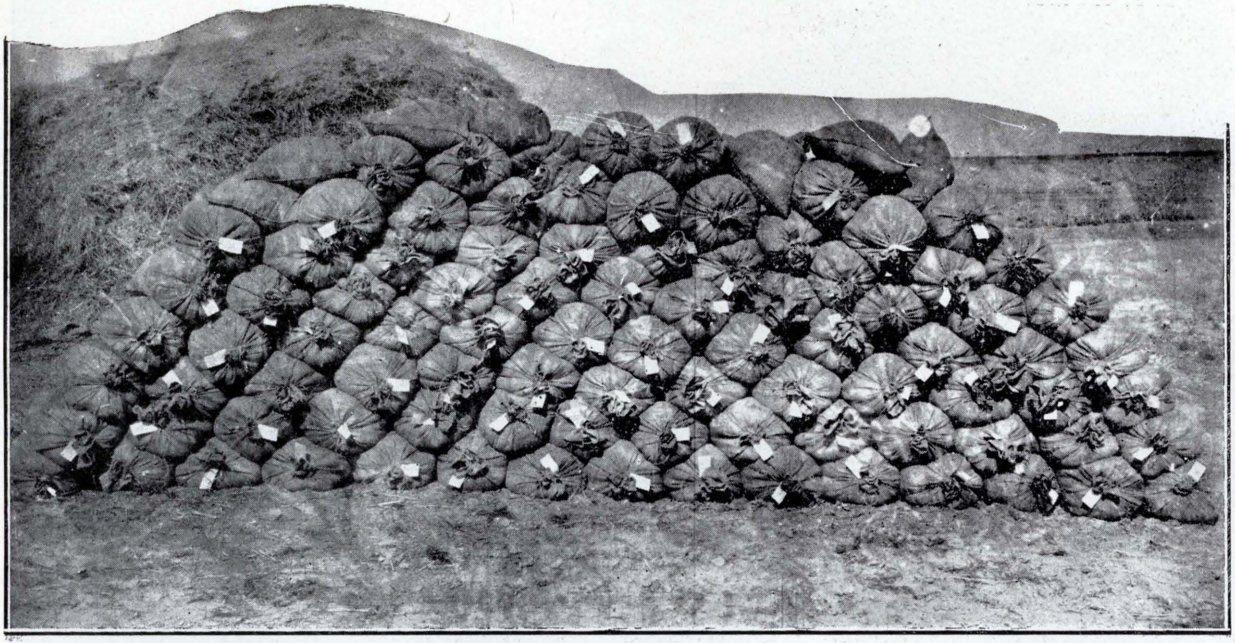

Fig. 8.—Grain Ready for Shipment from one of the Experimental Farms.

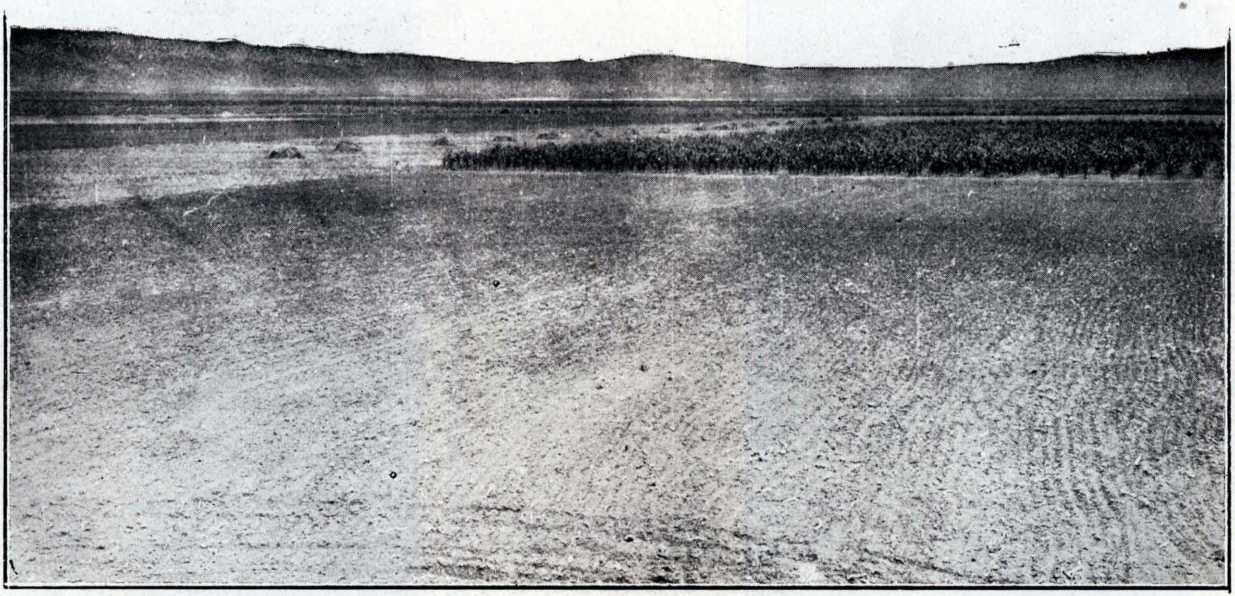

Fig. 9.—View on One of the Experimental Farms.

Fig. 10.—Excursionists to One of the Experimental Farms.

Fig. 11.—Excursionists to One of the Experimental Farms.

Fig. 12.—Selecting a Site for an Experimental Farm.

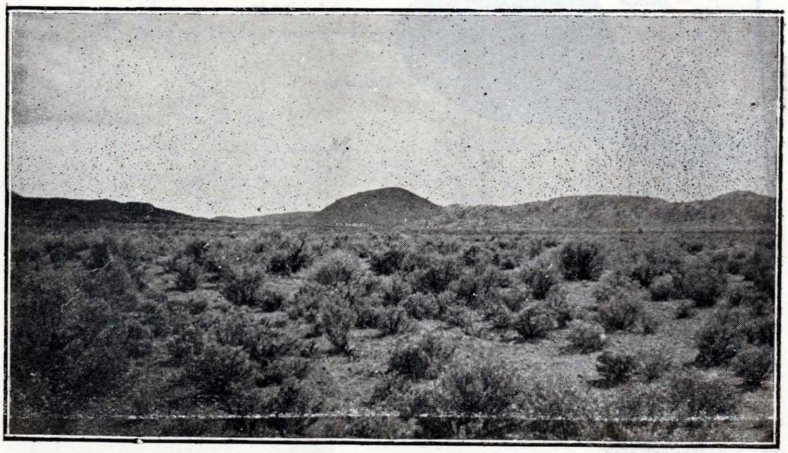

Fig. 13.—The Kind of Land to be Reclaimed.

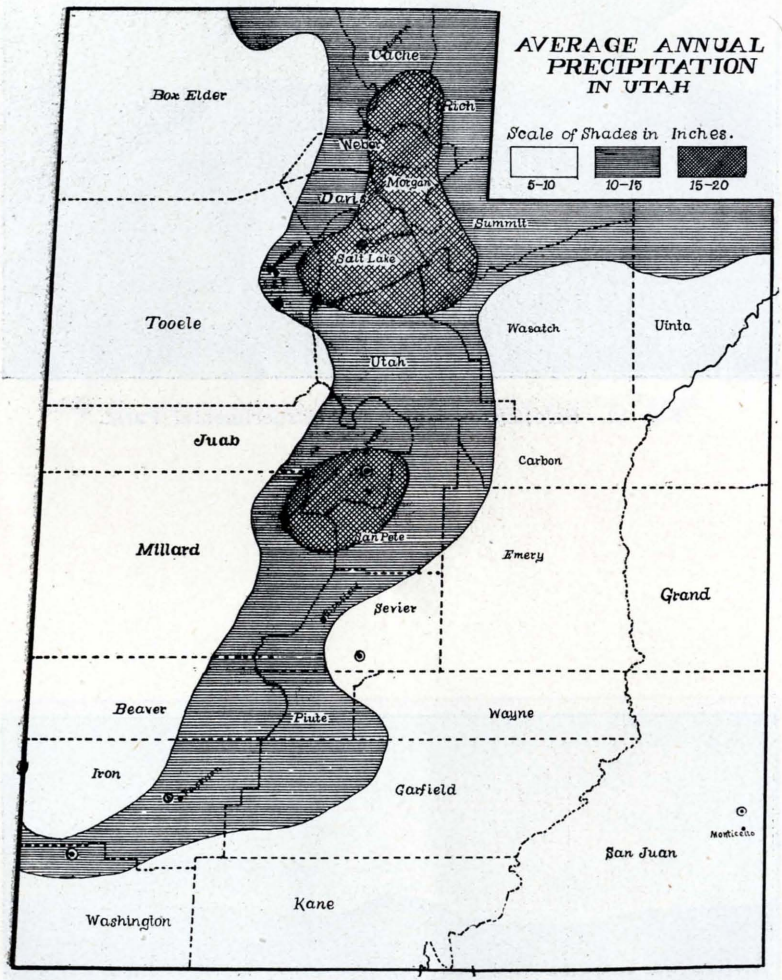

Fig. 14.—(The area not shaded. in the above cut. does not represent fairly the area that receives less than 10 inches precipitation annually. The absence of rainfall gauges in this district makes our knowledge of the precipitation uncertain.)

ARID FARMING IN UTAH.

(First Report of the State Experimental Arid Farms.)

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ARID FARMING IN UTAH.

(First Report of the State Experimental Arid Farms.)

JOHN A. WIDTSOE —LEWIS A. MERRILL.

A. GENERAL INTRODUCTION.

WHY ALL THIS TALK ABOUT ARID FARMING?

The present high position of Utah among the great commonwealths is due to the practice of irrigation. According to the last census, about 983 square miles are now being irrigated; and yet only a small fraction of Utah's water supply is used for purposes of irrigation. With the adoption of improved methods of using water, and the construction of mighty reservoirs to store the floods of spring, the irrigated area in this State will be largely increased. It is not at all improbable that in time the water supply may be made to irrigate ten times the area now under irrigation, though generations may pass before this is realized.

The total area of Utah is 82,190 square miles. The 983 square miles now under irrigation form a trifle more than one per cent of the land in the State; even when the irrigated area shall have been increased, in some happy future, to 10,000 square miles, only a little more than 12 per cent of our lands will be under irrigation farming. There will still be left over 72,000 square miles, or nearly 45,000,000 acres of arid land within the boundaries of the State. At the present time more than 50 million acres are unused. A large portion of these lands, perhaps one half, is mountainous; the remainder is located in the valleys and on the table lands of the State. In the mountains, where the sheep and the loggers have been controlled, trees, shrubs and grasses grow in considerable abundance; and the lower lands are covered, for the most part, with a luxurious growth of sage brush, greasewood, rabbit brush, sunflowers and other plants characteristic of western deserts. The soils are intrinsically fertile; the rainfall is low.

These millions of acres of unused lands—enough for the

founding of an empire—are in our State, and will ever remain here; there is no probability that by natural causes, the water supply will be increased sufficiently to irrigate the deserts; we are not now utilizing these lands; they are an undeveloped resource of the State. What can be done with these lands in order that they may aid in the development of the prosperity of our State? The indications of modern experience are that the deserts can be made wealth producers. How can this be done? These are questions which the serious, thinking lovers of this State hold to be of high importance, and which have led to the recent, general discussion of arid farming.

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2. EARLY ATTEMPTS AT ARID FARMING.

What can be done with the deserts? This question is not a new one. The pioneers of 1847, in the midst of the first canal building asked it; their descendants, after having extended the old canals and built new ones, still asked the same question; and to-day, when more land is irrigated than has ever been irrigated before, the thinking men of the community consider the serious question of utilizing the so-called dry lands of the State.

The pioneers of Utah had been brought up in countries where irrigation was an unknown practice. The artificial watering of the soil seemed to them an unattractive and laborious addition to the art of agriculture. Many of them, therefore, tried to raise different crops without irrigation. Among numerous failures, some trials proved successful. It was noticed, especially, that wheat and other grains, in certain districts, and in favorable years, gave fair returns without the addition of a drop of water, except such as fell as snow and rain.

At least as early as 1866, successful arid farming was practiced in Bear River City; and early in the seventies, arid farming was found to be profitable on the sand ridge between Ogden and Bountiful. Even to-day, the latter locality is covered with magnificent arid farms. Nearly twenty years ago, arid farming was tried in Cache Valley and the northern districts, and is now an established practice in those localities. In other places it seemed less successful. South of Salt Lake City, farming without irrigation has very seldom been tried, and until recently, a strong prejudice has existed there against the practice.

Within the last few years, the thoughts of Utah farmers have returned to the possibilities of the arid farm; for it seems that the growth of the population has been more rapid than the construction of canals, and, as a consequence, many young men have found themselves without sufficient irrigated land to consume all of their energies, and have been led into a study of the value of the arid farm. Others, again, have found that irrigated land, used for grain-raising, considering the cost of water, does not return a fair interest on the capital invested, and on the labor expended. Such thoughts have again led to the consideration of the arid farm, where grain may be grown at a small cost. There can be no doubt, in the minds of those who have studied the question, that extensive wheat growing on the irrigated lands of Utah, is a thing of the past. Sugar beets, potatoes, tomatoes, garden vegetables, fruit and other crops will cover the lands below the canals, while the wheat farms will be above.

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3. THE BEGINNING OF THE SYSTEMATIC STUDY OF ARID FARMING.

The possibilities of the reclamation of the deserts without irrigation has been a frequent topic of discussion among the officers of the Utah Experiment Station, since at least 1895. As our knowledge of the soil and climatic conditions of the State became more extensive and certain, it seemed more and more probable that certain crops could be grown profitably in many places without irrigation. At last, in the summer of 1901, the systematic investigation of the question was undertaken.

John A. Widtsoe and Lewis A. Merrill, director and agronomist, respectively, of the Utah Experiment Station, devoted a large portion of the summer to a study of the conditions under which successful arid farming was being practiced, and at the same time a careful study was made of the rainfall, and other climatic conditions prevailing in different parts of the State, with reference to the extension of arid farming. The results of this investigation were published as Bulletin No. 75 of the Experiment Station. The general conclusion of the work was that arid farming would undoubtedly be successful over a large portion of the State, including many of the southern districts. The suggestion was made

in this publication that to test so important a matter further, the State might establish a series of experimental farms in various portions of the State, upon which the possibilities of arid farming could be investigated in a thoroughly scientific manner. This report was widely circulated and attracted much notice.

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4. THE HISTORY OF THE ARID FARM BILL.

In accordance with the suggestion made in Bulletin No. 75, correspondence relating to the establishment of the experimental arid farms, was opened with Governor Heber M. Wells. The Governor took a lively interest in the matter, and assisted the cause materially by recommending, in his message to the legislature of 1903, that the proposed farms be established and supported by the State. His recommendation was as follows:

"A practical suggestion comes to me from the director of the Agricultural Experiment Station, at Logan, in reference to the establishment and maintenance, by the State, of a number of experimental farms for the purpose of demonstrating the best use to which the present unused or dry lands of the State may be put. Past experience in the reclamation and productiveness of lands long regarded as useless confirms the belief that the further agricultural possibilities of thousands of acres are scarcely dreamed of by the majority of our people. Just what these possibilities are, would be, of course, a matter of ascertainment by trial and experiment. Whether the sage brush and sunflower can be supplanted by drought-resisting forage plants that will yield at least one good crop a year, and whether in the economy of things the dry lands may be made to yield our wheat supply of the future, leaving the costly irrigated lands for more profitable crops—these are questions which the establishment and operation of small experimental farms in different sections would soon answer. These farms need not be large, perhaps covering not more than forty acres each. The land could no doubt be obtained without cost to the State. The expense of breaking the land, fencing, building sheds, and planting the first crop is estimated at not exceeding $7,500.00 for five forty-acre farms. The cost of carrying on experiments thereon might be $5,000 more per year. The work of demonstration could doubtless be finished in five years. The annual expense, after the first year, for labor, superintendence,

record keeping, preparing results for publication, printing, apparatus and incidentals, should not exceed $5,000.00. For the first five years, therefore, the cost would not be more than $27,500, while the resulting benefit to Utah Agriculture would in all probability be so great as to make the investment a splendidly profitable one. The subject is practical and interesting, and I present it as eminently worthy of your consideration."

Following the opening of the legislature, a bill was drafted by the director of the Station, which was submitted to the members of the legislative body. The bill was introduced in their respective houses, by Senator Henry Gardner and Representative Stephen L. Chipman. The bill immediately gained much friendly support and passed both houses without a dissenting vote.

Among those who gave especial assistance in making the bill a law were Senator Willis Johnson, and the late Apostle Abram Owen Woodruff.

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5. THE TEXT OF THE ARID FARM BILL.

EXPERIMENTAL FARMS ON ARID LANDS.

An Act establishing experimental farms to investigate and demonstrate the best methods of reclaiming the dry or arid or non-irrigated lands of the State of Utah, and making appropriation therefor.

Be it enacted by the Legislature of the State of Utah:

Section 1. Five experimental farms established. That in order to investigate and demonstrate the conditions under which useful plants may be grown on the dry or arid or non-irrigated lands of the State of Utah, and to determine the kind of plants best adapted for growth on these lands, there shall be established five experimental farms, or as many more as may be maintained by the appropriation designated in Section 7.

Sec. 2. Manner of conducting. That it shall be the duty of those having said experimental farms in charge to secure seeds from this and other countries of the world, of plants that are thought suitable for growth on dry lands, and to observe and record the growth, yield and composition of the plants grown from seed so secured; to investigate and determine the methods of soil

treatment by which the soil water is best conserved; to investigate the possibilities of grazing on dry lands which have been seeded to different crops, and to undertake such other experiments and demonstrations as may be deemed advisable, having in view the reclamation of the dry or arid lands of the State.

Sec. 3. Only one in a county. How selected. That not more than one of said experimental farms shall be located in one county; that the said experimental farms shall be located in districts where there are large areas of dry land, that may not in the near future be brought under irrigation; and that the locations of said experimental farms shall be selected under the direction of the board of trustees of the Agricultural College of Utah.

Sec. 4. Under direction of Agricultural College. That the actual work of experimentation and demonstration on said experimental farms shall be under the direction of the Agricultural Experiment Station of the State Agricultural College; that the officers of the said State Experiment Station, after having made selection of the locations of the said experimental farms, are hereby authorized and required to proceed to carry out the provisions of this act.

Sec. 5. Annual report to be published. That the State Experiment Station shall prepare and publish, or cause to be prepared and published, full and complete annual reports of the work accomplished on said experimental farms; that an edition of not less than 6,000 copies shall be published annually and distributed free of charge to all State and county officials, newspapers and interested citizens.

Sec. 6. To be maintained five years. That these exeprimental farms shall be maintained for a period of not less than five years from the date of the passage of this act.

Sec. 7. Appropriation. That for the purpose of carrying out the provisions of this act the sum of twelve thousand five hundred dollars is hereby appropriated from any moneys in the State Treasury not otherwise appropriated, and the State Auditor shall draw his warrant on the State Treasurer upon request in writing by the secretary of the board of trustees of the Agricultural College of Utah.

Sec. 8. County commisioners to provide site. Whenever the trustees of the Agricultural College desire to establish an experimental farm in any county, they shall as a condition precedent,

apply to the commissioners of such county to provide them with the gratuitous use of the required lands for the time needed, and upon the commissioners furnishing a requisite lease on suitable land, the said trustees may establish such farm.

Approved the 6th day of March, 1903.

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6. THE WORK OF LOCATING THE FARMS, AND THE INAUGURATION OF THE EXPERIMENTS.

In consonance with the directions of the law, the Board of Trustees of the Agricultural College, at the spring meeting of 1903, appointed a committee to select sites for the experimental farms. The members of the committee were: Hon. George C. Whitmore, member of the Board of Trustees, and Senator from the 9th District; Dr. John A. Widtsoe, Director of the Experiment Station, and Professor Lewis A. Merrill, Agronomist of the Experiment Station.

This committee began its labors on April 4th and reported its findings to the Board of Trustees on June 3rd, 1903. The following extracts from the report show the nature of its work:

"On April 8th we left for Juab County, and on the following day examined the country lying between Nephi and Levan. Juab Valley had previously been studied by representatives from the College, and special attention was, therefore, given only to those portions of the valley that were thought best adapted for arid farming. In Juab Valley, and in the valleys immediately to the west and south, are many thousands of acres of land suitable for farming without irrigation.

"On the evening of April 7th we left for Milford, Beaver County, and on the 8th we drove from Milford to Parowan, Iron County, by way of Minersville, examining the surrounding country as we travelled. The next day was spent in the vicinity of Parowan and Cedar City. In the valleys leading from Paragoonah through Parowan, Cedar City and south to Washington County are several hnudred thousand acres of deep fertile soil which receive a rainfall approximately equal to that of Cache Valley. On these lands arid farming will undoubtedly be successful.

"On the 10th of April we examined the country from Modena to Holt's Ranch, Washington County. In the vicinity of

Hebron and Enterprise and extending northward into the Escalante desert are several hundred thousand acres of the finest soil found in the State of Utah. As nearly as we can judge from available data, the precipitation there is not far from twelve inches, which would indicate successful arid farming. Soil samples taken at Parowan, Cedar City and Enterprise showed a large quantity of moisture in the soil.

"On April 11th we examined the country between Holt's ranch and St. George. The mountain meadows contained good soil, but the altitude is so high that in all probability early frosts will make arid farming there somewhat precarious.

"On April 12th the country around St. George and Santa Clara was examined. The soil there is tolerably good, but the rainfall is insufficient to make arid farming successful.

"On the 23rd of April the committee left Thompson's Springs, Grand County, for the purpose of studying the conditions in southeastern Utah. From Thompson's Springs to Moab neither soil nor rainfall conditions seemed suitable for arid farming. Likewise, the stretch of country extending twenty-five miles south of Moab seems unfit for the practice of farming without irrigation. However, about twenty miles southeast of Moab are several high mesas containing some 15,000 or more acres of land which will no doubt in time be made to yield crops without irrigation. Some miles south of Cane Springs, on the road between Moab and Monticello, there is an abrupt change in the nature of the country. From there on almost to the southern boundary of the county there are gently rolling hills covered with deep fertile soil on which sage brush and other native plants are growing in great luxuriance. The soil and rainfall conditions there indicate that arid farming will be a marked success. This country is so elevated that probably it will be impossible ever to bring it under irrigation, and it seems that it will remain undeveloped, agriculturally speaking, unless arid farming can be made a success there.

"A conservative estimate places the amount of land available for dry farm purposes in San Juan County at one million acres, of which 500,000 are covered with a fair growth of pine, while the other 500,000 are covered with sage brush and other related plants.

"On April 27th the committee studied the conditions in the vicinity of Price, Carbon County. Extending from Price south-

ward to Emery County are immense areas of fertile land, but the rainfall conditions and the results of the soil borings made by the committee, agreed in indicating the inadvisability of arid farming in that part of the State. North of Price, however, we found a number of mesas, the soils of which contain moisture enough to make arid farming a fair success, though the conditions there are in no way to be compared with those existing in San Juan County.

"On the 5th day of May the committee reached Manti, Sanpete County, and the following day gave the arid farming conditions of Sanpete County a careful investigation. The soils of Sanpete County are quite fertile; the rainfall is medium; and in all probability arid farming would be successful only in the smaller mountain valleys or on the lands forming the foothills of the mountains.

"The next day, May 6th, the committee traveled through Sevier Valley and found the conditions there very much the same as those that prevail in Sanpete County.

"On May 7th the committee visited Grass and Bear Valleys, and found there a considerable area of good soil with a very good rainfall. Soil borings and the native vegetation indicated that arid farming could be made a success there.

"On May 13th the committee studied the lands of Tooele Valley. The soil and meteorological conditions there are all favorable for arid farming.

"On May 14th the committe drove through the whole length of Rush Valley, a large portion of which can undoubtedly be brought under cultivation without irrigation. There are, in Tooele County, hundreds of thousands of acres of land that appear suitable for arid farming. The committee also gave attention to Cedar Valley in Utah County, which contains large areas of land that may be farmed without irrigation."

Acting on these findings, the Board of Trustees designated the country near Parowan, Iron County; Nephi, Juab County; Verdure, San Juan County; Plateau, Sevier County; Tooele and Grantsville, Tooele County, and Enterprise, Washington County, as locations for six experimental arid farms to be operated under the State law. In accordance with this decision, six farms of forty acres each were located as follows:

Iron County Farm—four miles west of Parowan.

Juab County Farm—About six miles south of Nephi.

San Juan County Farm—About six miles south of Monticello, near Verdure.

Sevier County Farm—In Grass Valley, about eighteen miles southeast of Richfield, near Burrville.

Tooele County Farm—About fourteen miles south of Grantsville and ten miles west of Tooele.

Washington County Farm—At Enterprise, eighteen miles from Modena.

Operations on these farms were begun at once, as reported later in this bulletin. A local foreman was appointed for each farm; the supervision of all field operations was delegated to Professor Lewis A. Merrill, while the chemical and other work was cared for by Dr. John A. Widtsoe. All the work was under the general supervision of the officers of the State Experiment Station.

Plans for the experiments were carefully formulated, and reported in a special publication entitled, *Memoranda of Arid Farm Investigations.*

The work has been pursued steadily since the farms were located, and with only such interruptions as were unavoidable.

7. THE ASSISTANCE OF THE COUNTIES.

Each county in which a farm was located donated the land, cleared the farm from sage brush, and gave it a first plowing, besides enclosing each farm with a rabbit tight fence. Numerous citizens took personal interest in the work, and rendered assistance that simplified the inauguration of the experimental work.

B. REASONS FOR BELIEVING ARID FARMING FEASIBLE.

8. THE AMOUNT OF WATER REQUIRED BY PLANTS.

Water is indispensable to plant life. It occurs, and must occur, in every portion of the plant, and all times of its existence, as long as life continues. Even after death, plants retain a small amount of water. Dry wood for instance, contains 10 per cent

to 15 per cent of water, and the driest flour on the market contains not less than 6 per cent.

Young growing plants frequently contain as much water as does rich cow's milk; a crop of field peas, two months after seeding, contained 88.30 per cent of water;* lucern cut on May 4th, contained 83.15 per cent;|| and a crop of oats contained on July 7th, 76.66 per cent. As the plant grows older the proportion of water decreases; for instance, the crop of field peas, three months after seeding, contained only 70.39 per cent water; the lucern on August 17th, 63.24 per cent, and the oats, on August 16th, when it was over-ripe, but 7.30 per cent.

When the plant is young, the leaves and the stalks contain about equal proportions of water. With increasing age, however, the proportion of water in the stalks becomes somewhat higher than that in the leaves, though the difference is never very great.

Plants obtain the water that they require from the soil. The fine root branches send out minute, delicate root hairs, that have the power of drawing water into themselves. These root hairs, as they forage about, come into contact with the soil grains, around which, if the soil contains moisture at all, the water is held as a thin film. The sucking of the root hairs makes the water film thinner, and water from adjoining soil particles is drawn upon to supply the plant. This is continued by the root hairs as long as there is water in the soil, or as long as the plant has need of water.

The water thus obtained is forced upward through the roots and stem, and most of it is finally evaporated from the leaves. From the soil, the plant takes many ingredients that are necessary to its growth; and these, owing to the upward movement of the water, are distributed, according to the needs of the plant, among the various plant parts. A portion of the water which reaches the leaves is caused to combine with the carbon, taken by the plant from the air, to form sugars, starches, oils and other important substances obtained from the vegetable kingdom. It may then be easily understood how important it is that water should be passing constantly through the plant, from root to leaf. If this movement is interrupted for a short time, serious injury to the plant follows.

The evaporation of water from the leaves of plants will naturally result in the consumption of large quantities of water, much larger than the quantity contained at any one time by the plant. In fact, a plant may be likened to a garden hose, which can

* Utah Bulletin, 69, p. 317. || Utah Bulletin. 48, p. 8.

hold but a few quarts of water, but through which hundreds of gallons may pass in one day. In all questions pertaining to irrigation or arid farming, it is of first importance to know how much water passes through the plant during the growing season, and the smallest current that will enable the plant to grow normally.

Experiments having this purpose in view have been made both in Europe and America; recently a large number have been carried on by the Utah Experiment Station under the peculiar climatic conditions that prevail in Utah.

In Europe and in the Eastern States, it has been found that to produce one pound of dry plant substance requires nearly 500 pounds of water. That is, one ton of absolutely dry lucern hay grown in a humid climate, is produced at an expense of about 500 tons of water.

In the drier climate of Utah, more water is ordinarily required to produce one pound of dry matter. Experiments on this subject, not yet published, indicate that on the arid farms about 750 pounds of water are required to produce one pound of dry plant substance.

The chief arid farm crop is wheat. Grown without irrigation, nearly one half of the wheat plant consists of the seeds or wheat kernels. Knowing that about 750 pounds of water are required to produce one pound of dry matter, it may be calculated that it will require 50 tons of water to produce one bushel of arid farm grain.

This seems a very large amount of water; yet, when compared with the amount of water that falls upon our soils in the form of snow or rain it is very small. For instance, a rainfall of one inch amounts to over 113 tons per acre, or more than enough if it could be used by the plant to produce two bushels of grain. Twelve inches of rainfall amount to 1361 tons of water per acre, or enough to produce 27 bushels of grain. Of course, as will be shown in a later paragraph, not all the water that falls on the soil is available to plants.

It may be added that the majority of cultivated plants need no more water than does wheat. In fact, the thrifty growth of sage brush and sunflowers found on our Utah deserts use as much water as many useful crops and are evidences that arid farming may be successful.

9. THE RAINFALL OF UTAH.

The present knowledge of the climate of Utah for agricultural purposes, is far from complete, though meteorological observations have been made for many years in a few easily accessible localities, and there is a very good comprehension of the general climate of the State. When, however, questions are asked concerning any particular locality, the answers are often unsatisfactory, since, for some of the more important agricultural districts, records of systematic meteorological observations are not at all to be found. The Utah Section of the Weather Bureau has established numerous new stations during the last few years, and data that will lead to a detailed knowledge of the climate of the State, are rapidly being accumulated.*

A somewhat careful analysis of the rainfall records up to January 1st, 1901, was given in Bulletin No. 75. For the purposes of this discussion the average total precipitation for a number of localities in the State, will be sufficient. The data have all been taken from the annual summary for 1903, of the Utah section of the climate and crop service of the Weather Bureau under the direction of Dr. R. J. Hyatt.

In the work of the Weather Bureau the State has been divided into three sections, each of which, so far as known, possesses an approximately uniform climate. The northern section includes roughly that portion of the State which lies north of an east and west line drawn through Provo; and includes Boxelder, Cache, Weber, Morgan, Davis, Summit, Salt Lake, Tooele, Utah, Wasatch, Rich and part of Uintah counties. The middle section extends south from the imaginary line through Provo to the southern boundaries of Beaver, Piute and Wayne counties; and is bounded on the east by Green River. The counties included by the middle section are Juab, Sanpete, Carbon, Emery, Sevier, Millard, Beaver, Piute and Wayne counties. The southern section extends from the southern boundary of the middle section to the Arizona line, and includes also the country lying east of Green and Colorado rivers. The counties embraced by this section are Iron, Garfield, Washington, Kane, San Juan and Grand.

The following table shows the normal annual rainfall at the

* Bulletin 47 of Utah Station, by James Dryden, gives a comprehensive summary of the climate of the State.

various stations of these sections, and also the average rainfall for each section and for the whole State.

NORMAL RAINFALL IN UTAH.

(To January 1st, 1904.)

NORTHERN.

STATIONS	Elevation (Feet)	Length of record (yrs)	Av. Precipitation (ins.)
Blue Creek	4387	26	8.44
Corinne	4240	34	12.14
Farmington	4267	4	18.39
Heber	5606	11	16.51
Henefer	5301	4	15.60
Huntsville	5100		15.26
Logan	4507	13	14.37
Meadowville	6200	4	13.25
Millville	4848		14.65
Ogden No. 1	4310	2	16.12
Ogden No. 2	4310	34	13.72
Salt Lake City	4366	30	16.19
Snowville	4360	14	10.93
Terrace	4550	33	4.67
Tooele	4900	8	13.75

MIDDLE.

STATIONS	Elevation (Feet)	Length of record (yrs.)	Av. Precipitation (ins.)
Black Rock	5802	3	9.12
Castle Dale	5500	5	4.48
Deseret	4541	10	7.34
Fillmore	5100	12	13.21
Government Creek	5277	3	11.53
Green River	4080	7	4.48
Levan	5010	14	14.62
Manti	5575	10	8.61
Mt. Nebo	4650	2	7.82
Mt. Pleasant	5859	12	12.18
Provo	4532	13	13.13
Richfield	5323	14	12.82

SOUTHERN.

STATIONS	Elevation (Feet)	Length of record (yrs.)	Av. Precipitation (ins.)
Aneth	4800	4	5.41
Frisco	7318	10	7.62
Giles	4066	9	3.90
Grover	5800	8	6.77
Hite	3000	4	3.12
Loa	7000	12	6.53
Lima	5092	3	9.63
Marysvale	6180	5	8.67
Moab	4000	15	7.41
Modena	5479	3	6.93
Monticello	7280	2	9.12
Parowan	5970	13	11.88
Pinto	5907	7	10.36
Plateau	7000	2	13.41
Ranch	6700	2	20.08
St. George	2880	18	6.72
Tropic	7000	7	8.13

It will be noticed from the above table that the precipitation varies greatly from place to place. For instance, in the northern section it varies from 18.39 to 4.67 inches; in the middle section from 14.62 to 4.48 inches, and in the southern section from 20.08 to 3.12 inches. With the comparatively few stations of the Weather Bureau, averages based on such figures have of course little practical value, and a map has therefore been constructed, based on the preceding tables, which shows the general distribution of heavy and light precipitation over the State. (See chart in front of this bulletin.) Even this map shows only the partial truth, for the want of stations makes the area that receives less than 10 inches appear much larger than it really is.

It may be observed from the preceding tables and from the rainfall map that there are large districts in the State that receive 12 inches of rain or more per year. As observed in the preceding discussion 12 inches of rainfall if wholly conserved would produce 27 bushels of wheat. If only half is kept in the soil there is a possibility of more than 13 bushels per acre, which is a very profitable yield. By the employment of proper methods of tillage, 10 inches or considerably less may be so conserved in the soil as to yield good crops. Where the rainfall is light, the land should be allowed to rest at least every other year, so that the pre-

cipitation of at least two years might be stored in the soil for the benefit of the next crop. It is commonly reported that in many places in California, where the rainfall is a little more than five inches, wheat and other crops are raised successfully without irrigation.

The rainfall data of the State indicate that profitable arid farming is possible over great portions of Utah.

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10. OTHER CLIMATIC CONDITIONS.

Plant growth can take place only at a definite temperature and in the presence of sufficient sunshine. These requirements are met especially well by the climate of Utah.

According to the report of the Utah Section of the Weather Bureau for 1903, there were 201 clear days, or 55 per cent during the whole year; 92 days, or 25 per cent, that were partly clear, and 72 days, or 20 per cent, that were cloudy. Considering the summer months, the proportion of sunny days becomes much higher, reaching 80 per cent or more. Since the important process of abstracting carbon from the air, takes place most rapidly in the presence of sunlight, it is evident that Utah crops are especially favored.

The temperature at which a plant can grow best varies somewhat with the surrounding conditions. It may be said, that the common grains do not germinate at a temperature lower than 40 degrees F., while growth begins at about 55 degrees F., and becomes more active as the temperature is increased, up to about 90 degrees F.

The records of the Weather Bureau show that the average temperature during the months of May to September (inclusive) throughout the State is about 65 degrees F. Thus, the favorable temperature extends over a long growing season.

It should be remembered that this temperature is the average of the highest and lowest points reached, and that the days are much warmer than the nights. Thus, the day temperature for May is near 85 degrees in the northern section, 90 degres in the middle section, and 95 degrees in the southern section; for June and July, 100 degrees, 105 degrees and 105 degrees; for August, 95 degrees, 100 degrees and 100 degrees; for September 85 degrees, 90 degrees and 90 degrees. Plant growth is therefore very active in

the daytime, and practically at a standstill during the hours of no sunshine. The moderate temperature that follows the early fall rains is of great value in giving the fall grain of the arid farms a first-class start.

The temperature and sunshine conditions in the State are favorable to arid farming, when a few high lying localities are excepted, that lie so high that spring frosts are late and autumn frosts come early. Even in such places, an intelligent system of culture can be made to ripen crops more rapidly, and thus, virtually, to lengthen the growing season.

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11. THE SOIL CONDITIONS.

Utah soils, like all those produced by arid conditions, are generally very deep, and very uniform,to great depths,in chemical and physical properties. The large valleys that constitute an important portion of the State, have level, plain-like floors, the bottom soils of which are often 100 to 200 feet deep; and every foot is suitable for agricultural purposes. Even on the side hills, the soils are deep—ten to one hundred feet—and it is only when steep mountain sides are reached that shallow soils predominate. There are, of course, some shallow soils in the State. These occur mostly on the "benches" near the mouths of canyons which are old deltas left by the prehistoric Lake Bonneville, that played so important a part in the making of the agricultural soils of the western half of the State. The benches or deltas found near the mouths of the canyons consist, as a rule, of coarse and fine gravel, sand, and clay, promiscuously thrown down by the canyon river as it entered the lake. The soils on these gravel banks are sometimes four inches, rarely more than three feet in depth; the average being perhaps less than one foot. In places there are pockets of sand or clay, a few square rods or at the most an acre or two in extent, in which the soil may be ten to twenty feet in depth. Such shallow soils are of little value for arid farming.

The prevailing great depth of Utah soils makes it possible for a large quantity of water to be stored in them. The average characteristic soils of the State, under ordinary conditions, are able to retain in each foot an amount of water that is approximately equivalent to 6.75 inches of rainfall. The average total rainfall for Utah is not far from 12 inches; which, then, could be retained

by about three and one quarter feet of soil. According to this calculation, a farm, the soil of which is 6.5 feet deep can retain, without loss by drainage, the total rainfall for two years; if 9.75 feet deep, the rainfall for three years, and so on. The storage of water applied to Utah soils is consequently tolerably certain; and the *problem before the arid farmer is to get as much as is possible of the rainfall and snowfall to soak into the soil* so that storage will be possible. The great depth of Utah soils is of importance to both arid and irrigation farmer. In the matter of depth and the consequently greater capacity for storing water, the soils of Utah are greatly superior, for arid farming, to soils of many other States.

In fertility the soils of Utah stand in the front ranks. By a proper system of fallowing and rotation of crops, there is no danger of the fertility decreasing to a point where profitable yields are impossible.

In Bulletin No. 75 a full discussion of the relation of soils to arid farming may be found. Under the arid farm law some important soil studies have also been made, that will be published later.

There can be no more favorable soil conditions for arid farming than those that prevail in Utah.

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12. THE REAL PROBLEMS OF ARID FARMING IN UTAH.

With sufficient precipitation and a favorable climate, the real problems that must be solved, in order to make arid farming successful, fall into two classes.

First. When no care is given the soil, much of the water that falls upon the soil either runs off into the washes, or is quickly evaporated into the air. The dry nature of the air, and the abundant sunshine make the loss due to the latter method very great. The arid farmer must therefore so treat his soil as to cause all or nearly all of the precipitation to enter it, and once the water is in the soil it must be kept there until it is needed by plants. This can be done only by the adoption and use of special cultural methods. To discover the best methods of culture for the conservation of rainfall and snowfall in the soil is the first real problem of arid farming.

Closely connected with this problem is that relating to the

modification of cultural methods required by the various kinds of soils. This is also of highest importance.

Second. After the water is in the soil, and is kept there by wise farming, it is necessary to plant crops that are adapted to the soils and climate, and that can get along with very little water. Such varieties of plants are not easily obtained. In fact, for the arid farms of Utah, it will be necessary to develop or modify varieties until they are adapted to the prevailing conditions.

Not only is it of importance to plant the right crop, but it is equally important to plant them at the right time, in the right manner and amount, and to care for them properly during growth. Special experiments are necessary to determine such methods.

Moreover, our present knowledge indicates that crops grown on the arid farms excel in quality, similar crops grown under humid conditions. Should this be found to be correct, it would increase, largely, the value of the products of arid farms. The study of the quality of crops grown without irrigation should be given immediate and full consideration.

All of these problems are difficult of solution; but, once solved, the results will have high economic value. Long continued, carefully planned and executed experimentation, alone, will solve these problems. Such work cannot be done by the farmer, but must be accomplished by the aid of trained scientific investigators. For the purpose of thus systematizing the principles of arid farming, and placing the practice on a rational basis, were the State Experimental Arid Farms established.

C. THE RESULTS ALREADY SECURED.

13. GENERAL.

Although the actual tillage operations have been in progress but one year much data, of a valuable nature, have already been secured. On all of the farms the yields with some of the crops were such as to encourage the belief that the deserts in the sections where the farms are located will ultimately be reclaimed. It is true that the results on all of the farms have not been equally encouraging but there are a great many factors which might affect this. The rainfall is not evenly distributed over the State

and the soil varies on the different farms from a very light sand to a heavy clay. Then too, experience has shown that two men working apparently like soils under exactly similar conditions will obtain very different crop results. We were under the necessity of securing inexperienced arid farmers as foremen and while they gave us their best efforts, yet many mistakes were made and the results were not as good as we have reason to expect for future years.

14. THE PLANS OF WORK.

The various farms were plotted or divided into plats, roadways, and paths. It was decided to do most of the cultural and other experimental work on the Juab and Iron County Farms, and each of these farms was therefore, divided into 170 plats, each plat being one-third of an acre in size. The Washington, Tooele, and San Juan Farms were each divided into one hundred plats, each plat being one-third of an acre in size, and the Sevier County Farm into sixty-three, one-half acre plats. Plans were prepared for the work on each plat of all of the farms and these plans were published as Circular No. 1. The plans included:

I. Variety Tests of Wheat, Oats, Barley, Lucern, Corn, Grasses, etc.
II. Depth of plowing tests.
III. Cultivation tests.
IV. Rate of seeding tests.
V. Time of seeding tests.
VI. Depth of seeding tests.
VII. Method of seeding tests.
VIII. Crop rotation tests.
IX. Fallowing tests.
X. Drouth resistant qualities of various crops as Millet, Kaffir Corn, Sugar-beets, Potatoes, Vetches, etc.

15. THE RAINFALL AND THE SEASON.

Rain gauges were established on all of the farms. Every precipitation of rain and snow was carefully measured. It would be of little value to discuss in detail the precipitation of one year, yet a brief consideration of the facts obtained may throw some light

on the results obtained from the cultural work. As rainfall data accumulate they will be of high value in furnishing a basis for the determination of localities that may be suitable for arid farming.

Some of the gauges were established in September, 1903; others in October and November of the same year. The following table shows the total precipitation in inches for the first twelve months:

Iron Co. Farm, 13.14; Juab Co. Farm, 11.91; San Juan Co. Farm, 10.26; Sevier Co. Farm, 10.58; Tooele Co. Farm 16.56; Washington Co. Farm, 11.94.

The precipitation on all the farms was above ten inches; the average was about 12.5 inches. By comparing this table with the discussion of yields from the various farms it will be found that the yields did not vary directly with the rainfall. As explained later, the previous condition of the soil; the treatment given it, and other factors are almost as important as the rainfall in determining the yield of crops.

The precipitation on all but the Tooele farm was very poor in the fall. The snowfall also was very light. As a consequence the fall germination was poor, and much winter killing was occasioned.

The question has been asked whether the year 1903-04 was not exceptionally wet. To answer this question the following table has been constructed which shows the average precipitation in the towns nearest the farms, and also the precipitation in these places from August 1903, to July, 1904, inclusive.

Place of Observation.	Length of Record (years)	Average precipitation (inches) ...	Precipitation Aug. 1903—July 1904 (inches)	Difference .....
Parowan, Iron Co.....	13	11.88	13.41	1.53
Levan, Juab Co.	14	14.62	15.64	1.02
Monticello, San Juan Co.	2	9.12	6.56	-2.56
Plateau, Sevier Co.....	2	13.41	17.86	4.45
Tooele, Tooele Co.	8	13.75	20.16	6.41

It will be noted that in all but one place, the rainfall during the twelve months, August, 1903—July, 1904, was higher than the average. In only two places was there any material increase. It will be noted also that in these places the rainfall record was of 2 and 8 years duration respectively. When it is recalled that during the past 5 or 6 years, seasons of excessive drought have prevailed, the average precipitation for the last 2 or 8 years would not represent fairly the average for the places in question over a long period of time, as for instance 25 years. It will also be noticed as a striking fact that at Levan and Parowan, where the rainfall record has been kept for 13 and 14 years respectively, the precipitation during the period involved, is only between one and two inches above the average. This again indicates that the rainfall of the last season was not far from the true average. At Monticello a very dry year prevailed. On the experimental farm, some miles away, much more precipitation was received. Considering the last 25 years, it can be safely said that the rainfall during the last growing season was not far from the average. With the land in better condition and with better seed, better results would have been obtained with less rainfall.

The whole question of the relation of rainfall to arid farming can be thoroughly discussed only after a record of several years has been obtained upon the experimental farms.

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16. THE SOIL CONDITIONS OF THE FARMS.

Soon after the farms had been secured, a most elaborate soil survey of each farm was made. This was thought advisable in view of the important relation which soils sustain to plants, both as regards plant food and capacity for water storage. The detailed report of the soil surveys, which will emphasize many important arid farm principles, will appear in a later bulletin.

The following table shows the amounts of gravel, sand, silt, and clay found in the most characteristic soil variety occurring on each farm:

MATERIAL	Iron County Farm	Juab County Farm	San Juan County Farm	Tooele County Farm	Sevier County Farm	Washington County Farm
PERCENTAGE COMPOSITION OF SOIL AS IT OCCURS.						
Gravel	1.28	9.59	1.05	5.34	20.58	9.93
Fine Soil	98.72	90.41	98.95	94.66	79.42	90.07
Total	100.00	100.00	100.00	100.00	100.00	100.00
PERCENTAGE COMPOSITION OF FINE SOIL.						
Sand	58.47	50.96	75.52	64.73	68.04	71.10
Silt	27.04	28.48	13.16	20.56	17.76	15.89
Clay	9.67	15.73	9.99	9.47	10.14	9.62
Total	95.18	95.17	98.67	94.76	95.94	96.61

It will be observed from this table that a great variety of soils is represented on the experimental farms. For instance, the gravel varies from 1.05 per cent, or nearly none, to 20.58 per cent, which is more than one-fifth of the total weight. The sand varies from 50.96 per cent to 75.52 per cent; the silt from 13.16 per cent to 28.48 per cent; and the clay from 9.62 per cent to 15.75 per cent. The most gravelly soil represents the most gravelly varieties in the State; the most sandy soil would be classed by the average observer as pure sand; the clay soil on the Juab Farm, is one of the heaviest varieties yet encountered in Utah. The chemical composition of the soils varies almost as much.

This wide range in the composition of the soils of the farms is very desirable, for it admits of a comparative study of different soils for the purposes of arid farming. It was explained in Bulletin No. 75, that as far as could be learned from a study of arid farming in Cache and Boxelder Counties, the physical composition of the soil made little or no difference in its power to yield crops without irrigation. Undoubtedly, however, the plant foods found in a soil, determine in a measure, the ease with which plants, having at their disposal a limited amount of water, can accomplish their life cycles.

These are questions of deep importance to arid farming, which will be discussed in a later bulletin.

17. THE SOIL TREATMENT.

In each instance the county fenced the forty acres selected by the Committee and cleared the ground from sage brush. As soon as the sagebrush was removed the ground was plowed, the instructions being to plow to a depth of ten inches. Some difficulty was experienced in plowing the ground to the required depth and on one farm (Washington County), the plowing was not over five or six inches, but on the remaining farms the plowing was done quite uniformly to the depth of eight inches. The harrow followed the plow, the ground being harrowed over until the surface soil was loose and fine. In some instances it was found necessary to disk the ground before it could be brought into the proper state of tilth but the smoothing harrow always followed the disk.

About one-half of the plats were summer fallowed during the season of 1904, these plats being kept free of weeds and under constant cultivation, in order to conserve the moisture for use during the season of 1905. Most of these plats were seeded during this fall (1904) and the remainder will be seeded early next spring. The results already secured are the products of but one year's precipitation and the Station workers have never maintained that with present cultural methods, large yields could be secured with but one year's precipitation but that the rainfall of two or even three years may be necessary for the production of profitable crops. With this condition in mind it is not surprising that better yields were not secured on the less successful farms and the marvel is that such satisfactory yields were secured under the existing conditions, even with the best farms.

18. VARIETY TESTS OF FALL WHEAT.

The following varieties of fall wheat were tested on the various farms: Lofthouse, Forty Fold or Gold Coin, Odessa, Blue Stem, Kofoid, Turkey, Mohamed ben bachir (7793), Red Chaff, Black Don (8232), Pellissier (7785), Pooling, New Zealand, Red Clawson, Egyptian Spring, Richi and Sonora. These

wheats had all been grown for at least one year, and many of them for several years, as arid farm wheats. Owing to the large amount of work connected with the inauguration of the experiments, the fall sown grain was not treated with any solution for the prevention of smut, and some smut therefore developed with two of the varieties, which were obtained for these experiments, in Juab County. It is generally recognized that the results of variety tests have little value unless they have extended through a number of years. We have decided therefore, not to make a detailed report of the first year's work, but after a few years, to publish a bulletin on varieties for arid farms. As examples of the variation in yield of the different varieties, the following table giving the yield of the various varieties of fall wheat from two of the farms are presented:

VARIETY TEST OF FALL WHEAT, JUAB AND TOOELE COUNTIES.

VARIETY.	Juab.	Tooele.
Odessa	20.5 bu	10.55 bu
Turkey	23.83 bu	11.14 bu
Red Chaff	22.08 bu	12.65 bu
Forty Fold (Gold Coin)	22.50 bu	15.20 bu
Blue Stem	13.75 bu	9.6 bu
Kofoid	18.91 bu	14.1 bu
Black Don (8232)	15.00 bu	.....
Pelissier (7785)	16.16 bu	.....
Lofthouse (Winter LaSelle)	16.16 bu	12.02 bu
Richi (7795)	.....	13.4 bu
Egyptian	.....	11.8 bu
Sonora	.....	12.8 bu

All wheat yields are based on 60 pounds per bushel.

From this table we find that while the Turkey yielded best in Juab County, there were five varieties which yielded better in Tooele County. In Iron County, of the fall varieties, Lofthouse wheat led with a yield of 9 bushels per acre, while in Sevier County, the Turkey wheat again led with a yield of 10.8 bushels per acre. In Washington County the Forty Fold or Gold Coin stood first in the list, the yield being 6.7 bushels per acre. All of the varieties used, with two exceptions, were choice varieties, and were selected because of the excellent showing they had previously made on arid lands. The two exceptions are Black Don (8232) and Pelissier (7785). These are Macaroni

varieties and were sent to us as spring wheats. They were planted in the fall, careful selections were made for two years and as seen by the table the yield this year was 15.0 and 16.16 bushels respectively. When these varieties become thoroughly acclimatized they will doubtless do much better. The chemical and milling qualities of these varieties are being studied this winter and a report on these will be made later.

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19. VARIETY TESTS WITH SPRING WHEAT.

The sowing of spring varieties on arid lands has never been considered advisable by the writers. We are convinced that better and surer returns may be expected where fall varieties are sown and the plant is given an opportunity to take advantage of th early spring rains and to mature before the hot and dry months of July and August. However, some of the arid farmers of the State still grow spring varieties, and we concluded, therefore, to include a list of spring varieties in this test. A number of macaroni wheats are in this list. The macaroni wheats belong to the botanical species "Triticum durum" and are sometimes known as "Goose," or "Rice" wheats. Commercially, the chief use of these wheats is for the manufacture of paste foods. Bread is however, made extensively from flour of macaroni wheat and while it is darker in color and heavier and tougher in structure than that made from flour of our ordinary wheats, yet it is considered more highly nutritious since durum wheats, as a rule, contain more proteid matter than the ordinary (vulgare) wheats. The heads of the macaroni wheats are all heavily bearded, being much more so than any of the ordinary wheats, and the plant when headed much resembles barley, visitors often insisting that it really is barley. The following varieties were planted on the Juab County Farm on March 19, 1904, at the rate of 3 pecks per acre and were harvested on July 28:

Modina (7794) yielded at the rate of 19.83 bu. per acre.

Adjini (7580) yielded at the rate of 11.50 bu. per acre.

Mohamed ben Bachir (7793) yielded at the rate of 21.25 bu. per acre.

Medeah (7579) yielded at the rate of 20.33 bu. per acre.

These are, on the average, exceptionally good yields but it must be remembered that the habits of growth of these wheats

adapt them to our arid conditions. For many years they have been grown without irrigation in an arid country and in consequence have great ability to withstand drouth and heat. From these yields it seems evident that plants long accustomed to peculiar conditions succeed much better on arid lands than plants grown under irrigation.

In Iron County only macaroni Spring wheats were grown and the highest yield in this test was obtained from Kahla which yielded 8 bushels per acre. In Sevier County, Northcotes Amber led in the Spring wheat variety test with a yield of 9½ bushels per acre. In Tooele County, a small red wheat sent to us from the Department of Agriculture some years ago, with a number (5644) but no name, gave best results, the yield being 14.1 bushels per acre.

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20. OATS.

We have not considered oats as among the possibilities for arid farming until very recently. Numerous inquiries have reached us concerning a fall variety of oats, but we have been unable to secure such a variety. The "Sixty Day" oats is a Russian variety imported by the United States Department of Agriculture several years ago, especially for the arid region. It is a vigorous but not a rank grower. The straw is very short but in our variety test at the home station, this variety has proved to be an exceptionally good yielder. This variety gave best results taken as a whole, on the arid farms.

YIELD OF OATS ON ARID FARMS.

Juab County—Sixty Day, 36.01; Giant Yellow, 34.07; Black American, 35.03.

Tooele County—Sixty Day, 17.25; Badger Queen, 11.91; Northwestern White, 17.25.

Sevier County—Sixty Day, 15.31.

Iron County—Sixty Day, 8.91; Prince Edward's Island, 3.12.

The Sixty Day Oats produced but 3.75 bushels per acre, in Washington County. From these yields it is evident that oats may be considered as one of the arid farm crops.

21. BARLEY.

The yields of barley were quite satisfactory for the first year, especially when we take into consideration the fact that we were compelled to use seed from irrigated farms, as we found it impossible to secure varieties from the "dry" farms. The yields given, then, represent the first year removed from irrigation, and on land recently plowed and in which there had been no opportunity to conserve moisture to any appreciable extent.

YIELDS OF BARLEY ON ARID FARMS.

Juab County—California, 34.9 bu.; California Prolific, 32.3 bu.; Success, 26.8 bu.

Iron County—California, 10.00 bu.; Manshury, 6.15 bu.

Washington County—California, 5.13 bu.

No attempt was made to grow barley on the other three farms this year but the success of this crop on these farms will warrant us in encouraging its growth on arid lands.

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22. RYE.

In selecting rye seed for use on the Arid Farms we succeeded in getting but one variety, and no name for that variety was known.

YIELDS OF RYE ON ARID FARMS.

Juab County—14.04 bushels per acre.

Iron County—11.55 bushels per acre.

At Washington County the rye yielded probably at the rate of 12 bushels per acre but as the birds destroyed the yields on the plats, no absolute results can be given. Rye was not sown on the other three farms but there is no doubt but that rye is one of the best drouth resisting cereals and in localities of limited rainfall, one of the crops most likely to succeed.

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23. EMMER.

Emmer, sometimes known as "Spelz," "Speltz," or "Spiltz,"

is a species of wheat and has special drouth resisting qualities. There is both a fall and spring variety, but the variety grown on these farms was the spring variety. It is said of emmer that "It will produce a fair crop under almost any conditions of soil and climate, but thrives best in a dry prairie region, with hot summers, where it gives excellent yields."

Emmer is used as a stock feed and compares well with oats and barley for this purpose. It is eaten readily by all kinds of stock but it has shown itself to be especially well adapted to milk cows. The hulls remain attached to the grain after threshing and this fact renders emmer less dangerous as a stock feed than wheat. It weighs 38 to 40 pounds per bushel.

YIELD OF EMMER.

Juab County—23.55 bushels per acre.

Tooele County—17.68 bushels per acre.

These are the only two farms on which emmer was tried and the yield was very satisfactory.

24. LUCERN.

Lucern was planted on all of the arid farms, part of the plats being planted in the fall and a part in the spring. The fall planting was a failure whenever tried. The spring planted plants were all successful; that is, a stand of lucern was obtained without a single failure on any of the farms. The tests with lucern include, I. A variety test with the Native, Turkestan, and Sand Lucern. II. A test of seed from an irrigated and an arid farm. III. Thickness of planting. IV. Method of planting, drilling, cross drilling, and broad-casting, and V. Time of seeding, fall or spring, and at various times during the spring. Some cultural work such as disking, cultivating, etc., will also be undertaken with this crop, during the coming season. This season after the lucern had attained a height of seven or eight inches it was mowed and left remaining on the ground The cutting was done in order that the root might have a chance to develop and that too much soil moisture might not be lost through the leaf surface. We are assured of a good crop of lucern next year and much valuable data on the crop will doubtless accumulate in a few years. On many arid farms through-

out the State, a good crop of lucern is secured for hay; the second crop gives a heavy and profitable yield of seed. Lucern growing, especially lucern seed production, is a reasonable possibility of the Utah desert.

25. CORN.

The growing of corn on arid lands has been practiced for many years in the arid farm districts of the State, and has been regarded feasible even where other crops were failures. Corn, which permits of intertillage, has come into quite general favor as an arid farm crop, but the fact that a very small amount of corn, either on irrigated or arid farms, is grown in the State would seem to indicate that this crop is not regarded in the light of a money making crop. Yet, corn can be successfully and profitably grown in this State, either on irrigated or arid lands, but more especially on arid lands.

The corn used for seed on these farms had been grown on dry land under the supervision of the Station, for three years, and was in consequence adapted for this test. The yield in Iron County (25.93 bushels of ear corn per acre) was the best yield obtained, but it is thought that with less seed, and with more experience in growing the crop, this yield can be materially increased, especially on summer fallowed land. Nearly a ton per acre of corn stover (excellent feed for cattle and sheep) was obtained in addition to the corn. With the exception of Sevier County, where early frosts prevented the corn from maturing, a crop was obtained on each of the farms.

26. SUGAR BEETS.

Sugar beets have never been regarded as an arid farm crop but were planted during the spring on each of the farms and the results were surprising. Many of the foremen had no previous experience with this crop and the seeding and thinning were imperfectly done; yet notwithstanding this, excellent beets were secured, many of them weighing from two and a half pounds to two pounds and ten ounces. The beets have been stored for mother beets; seed will be grown and an attempt made to produce an arid farm sugar beet.

27. GRASSES.

The following grasses have been sown on the various farms but it will, of course, be impossible to report on them until the end of next season. Bromus Inermis, Tall Meadow Oat Grass, Italian Rye Grass, Orchard Grass, Timothy, Wild Wheat Grass, Giant Wild Rye Grass and Agropyron Spicatum. The grass seed on most of the plats germinated and at this time gives promise of a successful stand.

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28. MISCELLANEOUS CROPS.

A number of crops were grown in small quantities to test their drouth resistant qualities. We were surprised in a number of instances with the vigorous growth made. Kaffir corn, Barn Yard Millet, Vetch and Dwarf Essex Rape all made satisfactory growth, though on some of the farms the crops were planted too thickly. A fair sample of potatoes was obtained from the Juab County Farm.

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29. THE EXHIBIT AT THE STATE FAIR.

It was thought that an exhibit of the actual products of the first year's work on the dry farms at the State Fair would reach a large number of people and stimulate an interest in the industry, and an exhibit was therefore made. Each of the Stations was represented at the fair by samples of the grains, grasses, and miscellaneous crops grown thereon, affording object lessons of the greatest worth to every intelligent farmer who took time to study the exhibit. The Salt Lake daily papers commented on the exhibit, and of the thousands who visited this section during the week, not one was heard to make an adverse criticism. Many encouraging and helpful suggestions were made, and the sentiment that the State was expending money wisely in this desert reclamation work, was, seemingly, universal. The Deseret Evening News discussing the exhibit has this to say:

"One year ago the farms were turned over to the Experiment Station, fenced and ready for the plow. They were covered with sagebrush and looked as uninviting from the standpoint of agriculture as could be imagined. The transformation from a desert to a fruitful field borders on the miraculous, and the result of the

first season's work—only one year removed from sagebrush barrens—is amost incredible. The crops of various varieties of wheat, oats, barley, rye, speltz, Indian and Kaffir corn, sorghum and alfalfa, show surprising yields, while the growth of potatoes and sugar beets, the only vegetable tested, promise wonderful possibilities."

On three successive days the Salt Lake Tribune called attention to the exhibit, and made the following editorial comment:

"A feature of this Fair never before seen is the extensive exhibit from the several dry farm stations of the State. The result of the present season's work on these dry farms will prove an eye-opener to the farmers generally, as the yield of grain from them without any irrigation at all and in a time of less than the normal precipitation during the growing season, is above the average from irrigated farms. We trust that all the farmers will pay especial attention to this exhibit, for it is likely to mark the introduction of a new era in the farming of the whole arid region. The exhibit is in the south-western corner of the building.

Some excellent specimens of flint corn ears more than 18 inches long, and over which the corn was uniformly distributed; lucern, two feet in length; brome grass 15 inches in length, and cereals fully the equal of anything that can be grown on irrigated lands were on exhibit. Such crops were the means of convincing many farmers and prominent business men of the State of the practicability of Arid Farming.

D. THE WORK YET TO BE DONE.

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30. THE WORK OF THIS YEAR MUST BE REPEATED.

As gratifying as the results of this season have been, next year's results will undoubtedly be much better. For next year's crop will have the summer fallowed land of one season in which the moisture of the past year has been accumulating. Then too, the seeds, some of which were taken from the irrigated farm for this year's work, will be better adapted. Another important factor is the experience gained by the Station workers and the local foremen in charge. It is only by the methodical application of the

principles of modern science to the problems of arid farming that the principles will be discovered, by means of which the deserts can be reclaimed successfully.

If the work as planned is carefully carried out for a series of years principles will be discovered which will enable arid farmers to follow certain definite scientific laws, in selecting seed, in planting and in harvesting and the business will no longer be followed in a haphazard way as at present. In the work of selecting varieties, it is important that the variety should have been under observation long enough to determine its good and bad qualities.

A single year's trial is not sufficient. So, too, with all of the problems connected with time of seeding, the amounts to sow, the depth of plowing, seeding, the frequency of tillage, etc. One year's work is not sufficient to answer these questions, but only after careful experimentation for several years will the problem find solution.

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31. A GREATER VARIETY OF CROPS MUST BE TESTED.

The working force engaged in these experiments has been limited both in numbers and time, so that it has been impossible to obtain for trial all the drouth resistant crops. There are many crops grown in other countries which may be of great value on our desert lands. These crops may have been grown for a great many years in countries of limited rainfall and on soils with an abundance and even an excess of soluble salts—conditions similar to those which obtain here—and when introduced may prove to be of great value. As these experiments progress, these crops will be introduced and a study of their adaptability and uses made.

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32. CULTURAL TESTS.

We have already inaugurated a number of tests involving the use of the disk plow, the subsoiler, the disk harrow, the Halleck Weeder, and various other cultural implements. We realize, however, that there are many other implements and devices for conserving moisture to be tried, and the introduction and testing of these implements is one of the plans of the future.

Arid farming differs from irrigation farming in that, since much smaller returns per acre are to be expected, a much larger area of land must be handled. Economical, yet efficient, methods of preparing the soil for seed, of seeding and of harvesting, will therefore need to be devised. It is possible that the advantages of co-operation in the way of tilling, plowing, reaping, and marketing will bring to this industry a rapid development, but the Station should make an extended study of these questions before suggesting their adoption by the farmers.

Plowing by steam power is practiced extensively on some of the large wheat farms of the central West and also on the Pacific Coast. It is possible that steam power can be used advantageously on large and extensive farms here. Steam plows are not profitable on small areas, but where several hundred acres are to be handled it is probable that it will be considerably cheaper than horse-power. The profitable use of steam machinery, the comparison of stationary and traction engines for plowing, the quickest and most profitable method of clearing the ground of sage brush, the seeding and reaping of large areas,—these are all questions for legitimate study on the part of the Station officers.

33. QUALITY OF CROPS GROWN.

It has been the custom for many years for the millers in this section to pay a better price for wheat grown on arid farms than for that from irrigated farms. This difference is based on the fact that arid farm wheat is really superior, containing as it does a higher per cent of protein, than does wheat from irrigated lands. In our irrigation experiments it was found that the amount of water applied affected strongly the proteid content of the wheat kernel; the plat receiving the least amount of water giving the highest per cent of protein.*

There has been considerable speculation during recent years concerning the comparative feeding value of irrigated and arid farm lucern. There is undoubtedly a distinct difference in the value of crops grown under these different conditions but all of these matters should be submitted to careful experimentation for their solution. It is our purpose to test the milling qualities of the

*See Bulletin No. 80, page 148, Utah Experiment Station.

various varieties of wheat grown on arid lands and a mill has already been provided for this purpose. There is a need for careful chemical analysis of all crops grown on these arid farms that the value of these crops may be determined, and, furthermore, it is probable that in these chemical studies further light may be obtained on the relations of arid plants to the soil and to moisture.

PRINCIPLES OF ARID FARMING.*

34. PLOWING.

To fully appreciate the necessity of plowing in arid farming, it is important to know the relation of the plant to the soil, and the method by which the plant obtains its moisture. While water is held in the soil in three different forms, viz: free, capillary, and hygroscopic water, it is only the capillary water which is a direct source of supply for plants. Capillary water is held as a distinct film around the soil grains. Fining and pulverizing the soil renders it possible for more capillary water to be held. Plowing the land has a very appreciable influence on the amount of water that can be held by the soil, as has been shown by many experimenters. At the time of seeding, this fall, the foremen on all of the farms noticed the great amount of moisture present in the land plowed a year ago—but which had not been cropped—as compared with that in adjacent fields, not plowed.

Some years ago the writers took samples of soil to a depth of five feet on two adjacent pieces of ground, one of which had never been plowed, the other having been cultivated for a great many years and from which a crop had just been removed. Notwithstanding the fact that the crop had used considerable quantities of moisture, there was still more than 53 tons per acre more water in the ground which had been plowed and cropped.

Plowing land in the fall has a very great influence on the per cent of water held in the soil. Some years ago samples were received from adjacent pieces of ground in the same field, one of which had been plowed in the fall and the other in the following

*This subject was discussed by the authors of this bulletin in Bulletin No. 75 of the Utah Experiment Station.

spring. The samples were secured on July 19th, and the accompanying table gives the results of the moisture determinations:

Inches	Fall Plowed per cent	Spring Plowed per cent	Difference per cent
0-12	18.07	18.49	0.42
12-24	24.69	20.41	4.28
24-36	22.18	19.55	2.63
36-48	33.90	23.24	10.66
48-60	40.90	29.28	10.81
Total water in inches	53.54	46.87	7.47

The table shows a very preceptible difference in favor of fall plowing, a difference amounting to one-third of the average rainfall of the year or more than 506 tons of water to the acre in the first five feet of soil. It will be observed that the difference in soil moisture is much more marked at the fifth and sixth feet. The moisture will be more effective in plant growth if found at this point, simply from the fact that it is less likely to be evaporated, than if found in the first or second foot. At this point the plant can obtain the moisture at the time when it is most needed. The Minnesota Experiment Station has shown that a wheat plant sixty-three days old, about two feet high and ready to head out, had roots which had "penetrated to the depth of more than four feet." The depth to which the roots will penetrate will depend very largely upon the character of the soil, the amount of water it holds, and the method of treatment. Although no data are at hand, it is believed that in this arid region the wheat plant sends its roots in search of water to even a greater depth than that given above.

On October 16, of the same year, samples were again taken from the same farm, this time to a depth of ten feet. The samples were taken in the near vicinity of those taken July 19th. In the meantime the farm had been seeded to wheat, and an excellent stand had already appeared.

INFLUENCE OF FALL PLOWING ON SOIL MOISTURE.

Inches	Fall Plowed per cent	Spring Plowed per cent	Difference per cent
0-12	23.75	17.44	6.31
12-24	23.83	17.72	6.11
24-36	28.11	18.07	10.04
36-48	32.98	22.55	10.43
48-60	33.15	29.28	3.87
60-72	33.33	31.67	1.66
72-84	36.69	35.61	1.08
84-96	41.11	36.76	4.35
96-108	39.08	37.63	1.45
108-120	36.17	36.39	0.22
Total water in inches	53.34	46.87	7.47

Here the difference in favor of fall plowing is marked. The amount of moisture in the first five feet of the land plowed in the fall was equal to 53.34 inches, while that of the spring plowed was 46.87 inches, a difference of 7.47 inches, or more than one-half of a year's precipitation in favor of fall plowing. While plowing is more difficult, and consequently more expensive, if done in the fall, the amount of moisture saved, and the increased yields, more than compensate for the extra expense. Another advantage of plowing in the fall is that the farm work is not so pressing as in the spring time, and hence the farmer has an opportunity to distribute his work more evenly over the year. The freezing and thawing during the winter also alter the texture of the soil, making it finer, and consequently keeping it in better condition for seeding.

The general consensus of opinion among arid farmers of experience is that deep plowing is much more effective than shallow plowing. The general practice on the dry farms is to use two teams of horses on a fourteen-inch sulky plow and turn the soil to a depth of eight to ten inches. On one large arid farm in Cache County, the practice of sub-soiling about 20 inches deep is followed at least once in three years. Most farmers, however, think it very doubtful whether this method of plowing has proved helpful enough to warrant the extra expense. Deep plowing is beneficial because it increases the moisture holding capacity of the soil and, as is believed by some, retains not only all the water added to it,

but also draws some moisture from the deeper layers gained through capillary action.

In an experiment conducted on the College farm some years ago, six plats were plowed ten inches deep and six adjacent plats plowed the same depth but subsoiled eight and one-half inches deeper. The yields during the four years of the experiment are rather interesting indicating as they do the advantages in the way of yield even when the soil is as shallow as that of the College farm.

AVERAGE YIELD IN BUSHELS PER ACRE OF SIX PLATS.

Year	Subsoiled	Not Subsoiled
1900	8.42	6.71
1901	8.94	8.44
1902	11.25	9.99
1903	9.02	8.09
Average for four years	9.41	8.31

These yields were obtained without summer fallowing on the shallow bench soil of the College Farm and where only the normal precipitation was available for the crop.

The results of this experiment indicate, strongly, that subsoiling favors the storing and retaining of the moisture that falls upon the ground. Future experiments, it is hoped, will demonstrate this more completely. Several years' experiments will be necessary to determine the place, subsoiling should have in Utah agriculture.

The theory has been advanced that, when the subsoil is loose and gravelly, no benefits will result from subsoiling, but on the contrary, much injury may be done. It is claimed that these soils, when subsoiled, lose a great deal of moisture which readily passes through them. In some sections of the country, east of us, the general experience has been favorable to subsoiling hard and compact soils. In this arid region, until further experiments are completed, it will be unwise to draw conclusions on the subject.

The experience of most Utah farmers has been that there is very little difference in the fertility of the soil and the subsoil. As a consequence there is little danger of plowing too deep. On most Utah farms, the luxuriant growth and larger yield on the

back furrows, compared with the scanty growth and small yield of the dead furrows emphasize the importance of a deep seed bed.

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35. FALLOWING.

The practice of leaving the land fallow or unoccupied every other season, or in some instances, every third season, is followed on most arid farms. It has been discovered that this method results in better yields than where the land is continuously cropped. The practice of fallowing originated in ancient times and is an outgrowth of the inferior implements of tillage used at that time. These tools did not stir and pulverize the soils sufficiently to render available the plant food already in the soil and in consequence it became necessary to allow the soil to weather and permit the growth and decay of vegetable matter.

On many well conducted farms intelligent rotation has been made to accomplish the results desired by fallowing. An intimate knowledge of the feeding habits and needs of various crops enables the wise farmer to grow these crops in such succession that plant food will be available to the crop at the time most needed. Another object aimed at in fallowing is the eradication of troublesome weeds. This can be accomplished by rotation. On our arid farms, however, the great object aimed at in fallowing is the storing up or conservation of moisture for the succeeding crop.

By proper methods of tillage the precipitation of two years may be stored in the soil and can be drawn upon by the crop when needed. On many Utah farms under irrigation, continuous crops of wheat have been produced on the same land twenty and even twenty-five years in succession, without any appreciable decrease yield. This proves the existence of a great store of plant foods in Utah soils. Such continuous cropping would be impossible on the arid farms, not because of lack of fertility, but because the precipitation of any one year is not always sufficient for a crop; and experience has shown that where the moisture of two seasons is used in the production of one crop, or even the moisture of three seasons used for two crops, better results are obtained. While it is true that lucern may be grown continuously on the same land, it must be kept in mind that this crop send its roots many feet into the ground in search of water, while wheat and other cereals draw only from a limited area. While the practice of summer fallowing

is not to be commended on many of the small, intensively cultivated farms of Utah, it certainly has its place on the arid farms. It may be wise on many of the arid farms where the soil is a light sand and lacking in plant food, to grow green crops, and plow them under when coming into head. Rye, vetch or clover may be sown in the fall after the wheat crop is removed and plowed under the next May or June. Any of these crops will grow readily on poor land and will furnish a large amount of vegetable matter to plow under. Clover or vetch will be better than the other crop mentioned because they would not only add vegetable matter to the soil, but during their period of growth they accumulate nitrogen from the air. The addition of this vegetable matter to the soil not only adds plant food, but aids in setting free some of the plant food already in the soil, making it available for the plant. It also aids light soils in absorbing and retaining moisture which is a very important consideration on arid farms. While green manuring has not come into general practice in Utah, it seems that the fertility, and moisture-holding capacity of many of our light soils might be materially increased by adopting this method. Where bare summer-fallowing is practiced, it rearely becomes necessary to plow more than once. The land should be plowed deep as soon as practicable after the crop is removed. Surface tillage may be made sufficient to keep the ground free from weeds and to give the land such preparation in preparing the seed bed as is necessary for the sowing of the seed in August and September. Of course the character of the first plowing, the weeds present and the soil, will determine whether it will be better to replow or simply to give surface tillage.

In brief, summer following clears the land of troublesome weeds; improves the physical condition of the soil, and makes available a larger amount of food and water supply. As to whether the fallow should come every second or third year will depend entirely on the character and condition of the land and the moisture available. Every arid farmer will have to study his own conditions and determine his policy from a knowledge of the particular needs.

36. SELECTION OF SEED AND SEEDING.

The practice among the arid farmers has been to sow from one and a half to two and a half bushels of seed wheat per acre. Experience has shown, however, that from one-half to one bushel per acre gives better results than where more seed is used.

After summer fallow there is usually ample moisture in the soil, which will, if the seed bed has been properly prepared, be sufficient to properly germinate one-half bushel of seed and this will furnish a sufficient number of plants to stool out for a sufficiently thick stand of wheat. Where wheat is grown on the same land two or more years in succession, the moisture in the soil at the time of seeding will be less, and the prospects of all the seeds germinating consequently lessened; and therefore, more seed should be used. Sometimes the soil is loose and open, or the season too far advanced before seeding, for the most favorable conditions for the "stooling out" of the wheat. In these cases a larger amount of seed will be necessary. The farmer must study his own individual conditions, and from his knowledge of the condition of his land, determine the amount of seed to sow. The experiments during the past year on the amount of seed gave such conflicting results that we have concluded that only continued experimentation through a series of years can give us results of any value. Often, on the arid farms, where the wheat shells badly before being cut, no seed is used. This method, however, is rather uncertain as to results and is not to be advised.

It is unfortunate for the wheat producers that a good variety of arid farm wheat has not been developed. Too many arid farmers are now growing mixed varieties, notwithstanding the fact that at least five cents per bushel more is paid for straight grades than for mixed.

The wheat plant (as every other plant) is affected either advantageously or disadvantageously by its environment. If wheat is grown on arid farms, it gradually adapts itself to arid conditions; hence the folly of obtaining seed from those who have grown it under irrigation, only because it is larger and plumper. A satisfactory variety should be chosen and by constant selection and grading, improved each year. In time the farmer who does this will have a ready market for his wheat, because of its uniformity. Farmers contemplating arid farming should obtain seed from an arid farm where a good variety has been grown, and by

careful yearly selection, develop a wheat suited to their conditions. Care should be exercised in the beginning to obtain good seed, known to have a record of large yields per acre, and then this seed should be retained year after year. Changing seed merely to make a change has its dangers in wheat growing even on the irrigated farms and to a greater extent on the arid farm.

As a result of a number of years experimenting with varieties we feel sure that the arid farmer will make no mistake in selecting any of the following varieties for fall seeding: Turkey, Gold Coin or Forty Fold, Winter La Salle or Lofthouse, Odessa, Red chaff, Blue Stem, Kofoid and Sonora. The important thing is to select some one variety and by careful selection improve that variety and not exchange for new and untried varieties.

As wheat is the principal crop of the arid farmer, the proper time at which it should be sown is an important consideration. Very little of the wheat grown on arid farms is spring sown, and this amount is growing less each year. When sown on summer fallowed land it has become customary to sow during the latter part of August or early in September. If following wheat, then the crop is removed as quickly as possible and the seeding is done as soon as the land can be prepared.

Few farmers now wait for the fall rains before seeding, as experience has generally shown that if the land is prepared and seeded as early as possible best results are secured. Oftentimes the seeding is done at a time when the surface is dry and dusty, but there is usually sufficient moisture two to four inches down to cause germination. Even if such conditions should not prevail, no harm results from the seed lying in the ground until the fall rains furnish sufficient moisture for germination.

A few arid farmers sow in the spring on account of the danger from winter killing. The past several winters have been attended with very little snow to afford protection for the tender wheat plant, and yet during this period there has not been extensive winter killing. We conclude that there is but little danger from this source and as a result of our observation and experience, would strongly advise sowing fall wheat on arid farms.

It is difficult to find an arid farmer now who sows his seeds broadcast. Press drills have come into almost general use and a drill is considered almost as essential in arid farming operations as a plow. With a drill the seed can be placed more evenly in

depth, and the depth to which the seed is to be sown can be regulated according to will. If the surface is dry, the wheat seed can be planted as deep as three and one-half inches. If before or just after fall rains the depth need not be greater than one inch. It is possible for the young plant to come up through three or four inches of loose earth, and if sown at this depth, the roots enter at once into the moist soil. The press drill is a very useful implement because it presses the light open soil around the seed, causing quicker germination and results in preventing the wind from carrying the soil away.

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37. HARVESTING.

A brief discussion of the general practice of harvesting wheat on arid farms may be of interest to those who are contemplating engaging in this industry. An effort has been made to reduce the expense of all the operations connected with arid farming to the minimum, and for this reason, methods of harvesting have been devised by means of which the expense is much less than formerly. The "header" has been found essential on the arid farms. Most of the manufacturers of implements have headers on the market, but all operate on the same general plan. Two teams are required to operate the header, and two to six teams, depending on the distance of the stack and the yield of grain, are required for the wagons on which are the boxes for removing the heads of grain from the field to the stack. As the cutting and stacking are done at the same time the expense of shocking the grain is dispensed with. If the grain, when headed, be properly stacked and covered, threshing may be delayed until a convenient time; whereas, when cut with a binder and shocked, there is always danger of mould in the shock when the fall rains begin, and consequently every farmer, under these circumstances, desires his threshing done at the earliest possible opportunity. Another advantage in the use of a header lies in the fact that only the heads of the grain are removed from the soil, leaving the straw, which when plowed under, assists materially in retaining soil mosture and fertility.

With a header, from twenty to twenty-five acres of grain are cut and stacked in one day. With a binder it is rarely possible to cut more than ten acres. In this fact lies one argument in favor

of the use of a header. Oftentimes the grain becomes very ripe before cut and it becomes desirable to harvest as quickly as possible to prevent shelling. The closed boxes used by the header also affords a much less chance of loss from shelling than where the binder is used and the bundle is handled several times before reaching the thresher.

The arid farmers in some sections of the State have already realized some of the advantages which come with mutual ownership of machinery, and in purchasing headers, it is the rule and not the exception, for one header to be owned by from two to six farmers. These farmers realize that if wheat is to be grown at a cost below the average cost to irrigation or humid farmers, and if results are to be secured which will be a fair profit on the capital invested, the most improved machinery must be brought into requisition, and this can be done, in many instances, only by cooperative ownership, by definite business methods, and by mutual confiidence in their neighboring farmers. It is obvious that where such a small yield per acre is secured, and where an interest in expensive machinery must be had, that arid farming can be successful only on large areas. One business management can handle vast tracts of land under arid conditions, and it seems useless to engage in the industry if this is the only source of income unless 160 acres are under tillage. It is more profitable if two quarter sections can be used, because of the necessity of summer-fallowing the land every other year, and the same implements, horses, etc., that are required to do the work for one quarter section can do the work on two farms of this size.

The energies of the arid farmers have so far, in the main, been bent in the direction of cheap production. It would seem desirable that this same ingenuity should be exerted in a more systematic and profitable method of marketing. The wheat of the arid farmer is sold miscellaneously on the market, no efforts having been made, through concerted effort to sell in bulk and directly to the flour manufacturers. Advantages of combination in the way of tilling, plowing, reaping, and marketing, which will eventually come to this industry, will result in its rapid development. The tendency on the irrigated farms of this State, with its rapidly increasing population, is toward small farms with more intensive cultivation. It is not possible, however, on the vast areas which can never be brought under irrigation, to till successfully a few acres. It is to

be hoped, however, that homes will be built on farms of this character, and that no more land will be secured than can be farmed well. If intelligence, industry and good judgment are brought to bear upon the cultural methods, essential to this industry, we need not fear a community of soil-robbers, but the farms may be made even better for future generations.

It is probable that the next few years will witness the introduction of steam machinery and combined harvesters and threshers on large arid farms throughout this region. Orcharding, dairying and sugar beet growing will undoubtedly take the place of wheat growing on the irrigated farms and thousands of acres of sage brush land will be converted into fields of grain. Thus a source of revenue will be opened up which was undreamed of by Utah's early settlers.